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be made at little expense, and sent to Sierra Leone and the Pontine Marshes; in the latter place the pumps might be worked by water conveyed from the mountains or other cheap motive power.

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Dr. Apjohn read a paper "On the hygrometric Correction in barometric Formulæ for the Measurements of Heights.

If the atmosphere were of one uniform temperature throughout, destitute of moisture, or in a constant hygrometric condition, and if the intensity of gravity were also constant, it is well known that the difference of the altitude of any two points in the atmosphere would be represented correctly by the formula  $d = m \times \log. \frac{p}{p'}$ ,  $m$  being a constant quantity, and  $p$  and  $p'$  being the respective pressures at the lower and upper stations, as measured by the barometer, or in any other way. A correction for temperature has been long applied by augmenting or diminishing the approximate height, or  $m \times \log. \frac{p}{p'}$ , by the amount that a column of air of this length would expand or contract if its temperature were changed from  $32^\circ$  to  $\frac{t + \theta}{2}$ ,  $t$  being the temperature of the lower, and  $\theta$  that of the upper extremity of the ærial column, by which the expression becomes

$$d = m \times \log. \frac{p}{p'} \times \left( 1 + \frac{\frac{t + \theta}{2} - 32}{493} \right).$$

Such is, I believe, a correct account of the present form of the barometric formula, at least when we neglect the correction for variations of gravity, which is, however, in general so small as to be safely negligible. The presence of moisture in the air, or rather its varying amount, must obviously exercise some disturbing effect on this formula; but

though this has been generally admitted by those who have turned their attention to the subject, I am not aware that any attempt at estimating its exact amount has been as yet made; and as the correction for moisture is frequently of considerable magnitude, and may, in my opinion, be applied with as much accuracy as that for temperature, I have taken the liberty of occupying, for a few moments, the time of the Academy with an explanation of the method which it has occurred to me to devise, and with which, from some trials I have made of it, I have every reason to be satisfied.

Let  $p$  be the pressure, and  $t$  the temperature of the air at the lower station,  $t''$  the dew point of the air, and  $f''$  the force of the included vapour; and let  $p'$ ,  $\theta$ ,  $\theta''$  and  $F''$  represent the corresponding quantities at the upper station. This being understood, a little consideration will suffice to shew that the presence of the aqueous vapour produces on the formula a twofold deranging effect. It augments the values of  $p$  and  $p'$  beyond what they would be in dry air, and it produces an alteration in the length of the column of air between the two stations additional to that which results from the difference between its mean temperature and  $32^\circ$ , or the freezing point. The first of these is obviated, or, in other words, the correction for it is made, by substituting for  $p$  and  $p'$  in the approximate formula,  $p - f''$  and  $p' - F''$ , by which it becomes

$$D = m \times \log. \frac{p - f''}{p' - F''}.$$

Having thus eliminated the effects of the tension of aqueous vapour upon the pressures, we have next to estimate the conjoint influence of it and temperature, in elongating the pillar of air between the two stations. The theory of mixed gases and vapours enables us to do this, provided we can assign proper mean values to the temperature, the pressure, and the force of vapour of the aerial column in ques-

tion. The mean temperature is usually taken as  $\frac{t + \theta}{2}$ , and this must be very nearly its true value. For the same reason, the mean force of vapours may be set down as  $\frac{f'' + F''}{2}$ ; and let us assume the mean value belonging to the pressure as  $\sqrt{(p - f'') \times (p' - F'')}$ .

Now a volume  $v$  of dry air at  $32^\circ$  under a pressure  $\pi$ , if raised to a temperature  $t''$ , becomes

$$v \times \frac{461 + t''}{493};$$

and if saturated with vapour at this temperature, the tension of such vapour being  $s''$ , it will become

$$v \times \frac{461 + t''}{493} \times \frac{\pi}{\pi - s''}.$$

This is the volume of the air when raised to  $t''$  and saturated with vapour at this temperature; and if this volume of air have its temperature further changed, we shall say to  $t$ , then its bulk will be represented by the expression

$$v \times \frac{461 + t''}{493} \times \frac{\pi}{\pi - s''} \times \frac{461 \pm t}{461 + t''} = v \times \frac{461 \pm t}{493} \times \frac{\pi}{\pi - s''};$$

substituting, then, in this expression instead of  $v$  the value of the length of the column of air between the two stations supposed dry, and at  $32^\circ$ , viz.:

$$m \times \log. \frac{p - f''}{p' - F''},$$

and for  $\pi$ ,  $t$ , and  $s''$  their proper mean values as already explained, the barometric formula finally becomes

$$D = m \times \log. \frac{p - f''}{p' - F''} \times \frac{461 \pm \frac{(t + \theta)}{2}}{493} \times \frac{\sqrt{(p - f'') \times (p' - F'')}}{\sqrt{(p - f'') \times (p' - F'')} - \frac{1}{2}(f'' + F'')}.$$

I may add here, that the correction for moisture is far from being insignificant in its amount, as may be seen by

the following example. Let us suppose, that when the approximate height, corrected for temperature, amounts to 2700 feet (a height reached by several of our Irish mountains), the mean value of  $\pi$ , or the pressure to be used in the final factor of the formula, is 27.3, and of the force of vapour, 0.3 of an inch, its value when the dew point is 43.6, then the elongation of the aerial column resulting from moisture is  $\frac{2}{3} \frac{3}{10} = \frac{1}{10}$ th of 2700 = 30 feet. It will, of course, have been observed that the correction for aqueous vapour differs from that for temperature in the circumstance of being always positive; and this coincides perfectly with the observation I have had frequent occasion of making, namely, that in damp states of the atmosphere heights calculated by the formulæ in general use are all appreciably less than the truth.

And here I may be permitted to observe, that the great Laplace, in discussing the barometric formula, in his "*Système du Monde*," has fallen into a slight oversight; for as a rude method of compensating for the effect of the aqueous vapour present in the atmosphere, he proposes, that in applying the correction for temperature the coefficient of the expansion of gases should be augmented from .00375, its value for one degree Centigrade, to .004. Now this would certainly produce the desired effect at all temperatures above 32°; but as below 32° this equation is subtractive, the augmentation of the coefficient, instead of diminishing, would increase the error. The following is the passage referred to:

"Les vapeurs aqueuses répandues dans l'atmosphère, étant moins denses que l'air, à la même pression et à la même température, elles diminuent la densité de l'atmosphère; et comme, tout étant égal d'ailleurs, elles sont plus abondantes dans les grandes chaleurs; on y aura égard en partie, en augmentant un peu le nombre .00375 qui exprime la dilatation de l'air pour chaque degré du thermomètre. Je trouve que l'on satisfait assez bien à l'ensemble des observations, en le portant à 0,004; on pourra donc faire usage

de ce dernier nombre, du moins jusqu'à ce que l'on soit parvenu par une longue suite d'observations sur l'hygromètre, à introduire cet instrument dans la mesure des hauteurs par le baromètre."\*

I may in conclusion observe, that in assuming, with the view of calculating the expansion produced by moisture, that the pressure to be employed is the geometric mean of the corrected pressures given by the barometer at the two stations, I am quite aware that I am assigning to it but an approximate value. An exact expression for the pressure to be employed admits of being investigated;† but its introduction into the formula, while it would give the latter complexity of form, and thus render it less suited for practical use, would conduct to results not appreciably different from those given by the more simple methods just explained.

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Mr. Clibborn presented to the Acadcmy an ancient stone image, called in some places a Shela-na-gig; and read the following extract from a letter from Dr. Charles Halpin :

“ About two years ago, as I drove past the *old graveyard* of Lavey Church, I discovered this curious figure, laid loosely, in a half reclining position, on the top of a gate pier that had been built recently, to hang a gate upon, at the ancient entrance of the old church-yard. I believe the stones used in building those piers were taken from the ruins of

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\* Systeme du Monde, p. 89.

† Let  $\frac{\log. \frac{p}{p'}}{m\left(\frac{1}{p'} - \frac{1}{p}\right)}$ ,  $m$  being the modulus of the common system of logarithms,  $= P$ . Then if  $v$  be the column of dry air, and that, when saturated with moisture whose force is  $f$ , it becomes  $v'$ , we will have

$$v' = v \times \frac{P}{P - f}.$$

For the very elegant expression for  $P$  I am indebted to my friend, Professor Renny.